

What is claimed is:

1. A method for clock and carrier recovery at a receiver of a direct sequence spread spectrum communication system, the clock and carrier recovery being accomplished using a predefined training sequence or unknown data sequence, each symbol of the predefined training sequence being spread by a predefined spreading sequence, the predefined training sequence being transmitted on a channel by a transmitter, a signal corresponding to the transmitted training sequence being received by the receiver, the method comprising the steps of:

- a. down-converting the received signal to convert it to baseband of the frequency spectrum;
- b. sampling the down-converted signal at a pre-defined sampling rate to obtain samples of the received signal;
- c. estimating the symbol boundary using the samples of the received signal;
- d. computing the maximum likelihood estimate of the mean of the phase error;
- e. computing the maximum likelihood estimate of the carrier frequency offset using the maximum likelihood estimate of the mean of the phase error; and
- f. computing the maximum likelihood estimate of the clock error.

2. The method as recited in claim 1 wherein the step of computing the maximum likelihood estimate of the mean of the phase error comprises the steps of:

- a. setting a counter to an initial value of zero;
- b. buffering M samples of the signal with boundary alignment, where M is a pre-defined number;

- c. decimating to retain N samples of the M buffered samples, where N is the length of the pre-defined spreading sequence;
- d. de-spreading the decimated samples of the down-converted signal using the pre-defined spreading code to obtain a sequence of de-spread symbols;
- e. forming a differential symbol using the de-spread symbols;
- f. extracting the phase angle of the differential symbol;
- g. performing a symbol decision on the phase angle;
- h. computing the phase error introduced in the transmitted signals;
- i. accumulating the phase error using maximum likelihood weighting scheme;
- j. incrementing the value of the counter by unity; and
- k. repeating steps b-j until the value of the counter reaches a value L , L being the estimation length in terms of the number of Differential Binary Phase Shift Keying symbols.

3. The method as recited in claim 2 wherein the step of accumulating the phase error comprises accumulating the phase error using the maximum likelihood weighting scheme.
4. A system for clock and carrier recovery at a receiver of a direct sequence spread spectrum communication system, the clock and carrier recovery being accomplished using a predefined training sequence or unknown data sequence, each symbol of the predefined training sequence being spread by a predefined spreading sequence, the predefined training sequence being transmitted on a

channel by a transmitter, a signal corresponding to the transmitted training sequence being received by the receiver, the system comprising:

- a. a Down Converter down-converting the received signal to convert it to baseband of the frequency spectrum;
 - 5 b. a Sampler sampling the received signal at a predefined sampling rate to obtain samples of the received signal;
 - c. a Symbol Boundary Estimator estimating a symbol boundary using the samples of the received signal;
 - d. a Phase Error Estimator computing the maximum likelihood estimate of
10 the mean of the phase error;
 - e. a Carrier Frequency Offset Estimator computing the maximum likelihood estimate of the carrier frequency offset; and
 - f. a Clock Error Estimator computing the maximum likelihood estimate of the clock error.
- 15 5. The system as recited in claim 4 wherein the Phase Error Estimator comprises:
- a. a Buffer buffering M samples of the signal with boundary alignment, where M is a pre-defined number;
 - b. a Decimator decimating the buffered samples to retain N samples of the M buffered samples, where N is the length of a pre-defined spreading
20 sequence;
 - c. a De-spreader de-spreading the decimated samples of the down-converted signal using the pre-defined spreading code to obtain a sequence of de-spread symbols;

- d. a Differential Symbol Calculator forming a differential symbol using the de-spread symbols;
 - e. a Phase Angle Extractor extracting the phase angle of the differential symbol;
 - 5 f. a Symbol Decider performing a symbol decision on the phase angle;
 - g. a Phase Error Calculator computing the phase error introduced in the transmitted signals; and
 - h. a Phase Error Accumulator accumulating the phase error using the maximum likelihood weighting scheme.
- 10 6. A computer program product for clock and carrier recovery at a receiver of a direct sequence spread spectrum communication system, the clock and carrier recovery being accomplished using a predefined training sequence or unknown data sequence, each symbol of the predefined training sequence being spread by a predefined spreading sequence, the predefined training sequence being
- 15 transmitted on a channel by a transmitter, a signal corresponding to the transmitted training sequence being received by the receiver, the computer program product comprising:
- a computer readable medium comprising:
- a. instruction means for down-converting the received signal to convert it to
 - 20 baseband of the frequency spectrum;
 - b. instruction means for sampling the down-converted signal at a pre-defined sampling rate to obtain samples of the received signal;

- c. instruction means for estimating the symbol boundary using the samples of the received signal;
 - d. instruction means for computing the maximum likelihood estimate of the mean of the phase error;
 - 5 e. instruction means for computing the maximum likelihood estimate of the carrier frequency offset using the maximum likelihood estimate of the mean of the phase error; and
 - f. instruction means for computing the maximum likelihood estimate of the clock error.
- 10 7. The computer program product as recited in claim 6 wherein the instruction means for computing the maximum likelihood estimate of the mean of the phase error comprises:
- a computer readable medium comprising:
- a. instruction means for setting a counter to an initial value of zero;
 - 15 b. instruction means for buffering M samples of the signal with boundary alignment, where M is a pre-defined number;
 - c. instruction means for decimating to retain N samples of the M buffered samples, where N is the length of a pre-defined sequence;
 - d. instruction means for de-spreading the decimated samples of the down-converted signal using the pre-defined spreading code to obtain a
 - 20 sequence of de-spread symbols;
 - e. instruction means for forming a differential symbol using the de-spread symbols;

- f. instruction means for extracting the phase angle of the differential symbol;
- g. instruction means for performing a symbol decision on the phase angle;
- h. instruction means for computing the phase error introduced in the transmitted signals;

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- i. instruction means for accumulating the phase error using the maximum likelihood weighting scheme;

- j. instruction means for incrementing the value of the counter by unity; and

- k. instruction means for repeating steps b-j until the value of the counter reaches a value L , L being the estimation length in terms of the number of

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Differential Binary Phase Shift Keying symbols.